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A study of the cuessing frequencies for 'homographic' nonsense words with experimentally produced meanings

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A STUDY OF THE GUESSING FREQUENCIES FOR 'HOMOGRAPHIC' NONSENSE WORDS WITH EXPERIMENTALLY PRODUCED MEANINGS

by
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ABSTRACT

Words that an individual has experienced frequently are recognized more easily, when presented very briefly or in a noisy background, than words experienced less frequently. This 'word frequency effect' has been shown for a variety of verbal materials. In a recent experiment using homographic English words, by Rubenstein, Garfield and Millikan, however, an anomolous result was observed. While a word frequency effect was found to occur for homographs, recognition time was shorter than for non-homographs of the same frequency.

In the present experiment, we wished to see whether an analogous effect would occur with emission of homographic nonsense words. Subjects were taught CVC's, some with one meaning and some with two, in a paired-associate task. They then guessed the CVC's in a tachistoscopic 'recognition' task, which they had been lead to believe was on subliminal perception.

Although a word-frequency effect did occur for the materials, recognition time for homographs was not found to be greater than for non-homographs.

Some speculative suggestions for the non-occurrence of a homograph effect in this study are discussed, and one possible mechanism for the occurrence of the effect in natural language suggested briefly.

INTRODUCTION

Words which have occurred frequently in an individual's experience are more easily recognized, when presented very briefly or in noise, than words which have occurred less frequently. This effect - the 'word-frequency effect' - has been observed, in a variety of experimental conditions, for words in natural language as well as for artificial words (CVC's, paralogs, and statistical approximations to English).

For natural English words, the frequency of occurrence of a word in a large sample of English text (often the Thorndike-Lorge count) has usually been assumed to approximate the frequency with which an observer has experienced the word. For artificial words, frequency of exposure has been experimentally controlled. In both cases, however, the relation between frequency and ease of recognition is clear: the more frequent the word, the easier it is to recognize it. Furthermore, the relationship is a functional one, recognition time appears to be a function of the logarithm of word frequency. This relationship is fairly well established, although the mechanism which produces it is far from clear.

These results have been found to apply to a variety of verbal materials. However, in a recent experiment by Rubenstein _et. al_., a curious phenomenon was observed: recognition time for homographs - words with two or more meanings - was faster than for non-homographs of the same frequency of occurrence (Rubenstein, Garfield and Millikan). While a word-frequency effect was still observed for homographs, the function relating frequency to recognition time was different, with homographic recognition being faster.

This finding, which has since been replicated (Gough), is decidedly counter-intuitive. At issue is the question: in a recognition task, is a homograph acting as <u>one</u> word, with overall frequency equal to the sum of the frequencies of the individual meanings, or is a homograph effectively acting as <u>several</u> separate words, each with its own frequency of occurrence. In the first case, one might expect the word-frequency effect to be the same for homographs and for non-homographs; in the second, one might expect the recognition time for homographs to be <u>slower</u> than for non-homographs of the same frequency. But the Rubenstein *et. al.*, effect did not conform to either of these quite natural expectations.

An example should clarify the counter-intuitive nature of these results. Let us consider the homograph, <u>crane</u>, with its two meanings: <u>crane</u> (bird) and <u>crane</u> (derrick). Assume, in some hypothetical sample of English, that the word-form 'crane' appears 100 times. Assume further, for simplicity, that each meaning of crane appears 50 times. And assume that the non-homograph, <u>desk</u>, occurs 100 times.

Then if the frequency of the word-form <u>crane</u> is operating in producing the word frequency effect, recognition time for <u>desk</u> and for <u>crane</u> should be equal, since the frequency of each is 100. But if each meaning of <u>crane</u> operates, essentially, as a separate word, then, e.g. crane (bird) with half as many occurrences, should be recognized more slowly than desk. But, on the contrary, in the Rubenstein et. al. experiment, the homographs, such as crane, were recognized more quickly!

MOTIVATION

The present paper reports an attempt to see whether an analogous homograph effect would occur with CVC's, as well as with natural English words. Specifically, we wished to determine whether the frequency of emission of 'homographic' nonsense terms, which had been given two meanings in a paired-associate task, would be greater than that of non-homographic nonsense terms to which a subject had been exposed the same number of times.

A suggestion by Rubenstein et. al. prompted the study. Looking for an explanation of the 'homograph effect' - the shorter recognition time for homographs - they suggested a mechanism based on: 1) random search in an internal lexicon, and 2) multiple storage of homographs in such a lexicon. If encountering either one of the multiply-stored homographs terminated a search, recognition time for homographs could be faster. Rubenstein et. al. further suggest a mathematical relationship that might account for their results, namely, that the recognition time is '. . . a function of the sum of the logarithms of the meaning frequencies rather than the logarithm of the sum of the meaning frequencies.' We wished to explore this suggestion.

APPROACH

The approach is a variation of Goldiamond and Hawkins 'Vexierversuch', or hoax experiment (Goldiamond and Hawkins, 1958). Having told their subjects that the experiment was on subliminal perception, but actually flashing blanks, Goldiamond and Hawkins attempted to show that the word-frequency effect could be accounted for entirely by a response bias - a predisposition to respond with high frequency terms - without regard to perception. We, however, are considering the zero-perception case as a limiting case of the more general perceptual experiment, with no further claims or interest in the response bias versus perception issue.

The current experiment consisted of two tasks: a paired-associate learning task, in which English 'meanings' were associated with CVC's, and a tachistoscopic 'recognition' task. Two sets of nonsense words (CVC's) were used in the paired associate task:

a) 'Homographic' nonsense words, which had each been associated with two English words (meanings)

b) Non-homographic nonsense words, each with only one associated meaning.

Subjects were asked to learn the nonsense terms and their meaning(s) by reading aloud from cards on which a nonsense-English pair had been typed. Frequency of presentation of the pairs was varied.

Following the paired-associate task was a 'recognition' session, similar to the Goldiamond and Hawkins procedure, with the CVC's from the paired-associate training phase as 'stimuli'. Subjects were told that the experiment was on subliminal perception.

METHOD

Subjects

24 undergraduate psychology students at Lehigh University served to fulfill part of a course requirement in elementary psychology.

Materials: Paired Associate Training phase

1. Nonsense words: 8 CVC's of low association value (at or below m=25) selected from Archer's (1960) list of all possible CVC's: ZUN, YAD, TOV, DAX, JOM, VAB, GEC, FEP. The CVC's differ in first and last letters, to reduce the possibility of intra-list confusions, and were judged to be reasonably pronounceable, for relative ease of learning.

2. English words: 12 English disyllables, all with similar (high) association values, selected from Noble's (1952) list (m range, 6.75-9.61): kitchen, typhoon, money, insect, captain, jewel, wagon, heaven, zebra, office, village, youngster.

Six decks of 3 X 5 cards were prepared, with one nonsense-English pair per card. 'Homographic' nonsense terms were presented on separate cards, one card for each 'meaning'. The frequencies of presentation were: 2, 4, 8, and 16, with words to be presented 16 times typed on 16 cards, etc.

The number of presentations of homographic and non-homographic

CVC's was equated, with both 'meanings' of a homographic CVC appearing an equal number of times. Thus if the total frequency of presentation of a particular homographic CVC were 16, there would be 8 cards with the CVC paired with one of its meanings and 8 cards with the CVC and its other associated meaning. One deck of cards thus contained a total of 60 cards.

Six different decks were prepared, with different randomizations of the materials, and each deck was used for 4 of the 24 subjects. In preparing each deck, 4 CVC's were chosen at random to be homographs (have two 'meanings' assigned), and the other 4 were non-homographs. 'Meanings' were then assigned to the CVC's, also at random, but with the restriction that no nonsense-English pair should start or end with the same letter. Each deck was then divided into 4 sections, each section shuffled individually, and the 4 sections then recombined, without further shuffling, to prevent undue pile-ups at the beginning or the end of the deck.

<u>Materials</u>: <u>Tachistoscopic 'recognition' phase</u>

48 slides, of white cardboard, about 6 X 10 inches, were prepared for use in a Gerbrands tachistoscope. Although the presentation time was intended to be fast enough to preclude seeing any of the slides, we thought something should still be on them. Therefore, a series of three identical letters, none of which appeared in any of the CVC's, was typed in the center of these cards, *viz*: KKK, III, LLL, HHH. Each of the 4 series

of identical letters was typed on 12 cards. For viewing, the slides were alternated, in sequence, as an extra precaution, since it has been shown that repeated presentation of the same stimulus can result in improved perception, even when duration of presentation is not increased. (Haber and Hershensen)

Procedure: Paired associate training phase

Subjects were told that this part of the experiment was like learning a foreign language, and that they should read the words on each card aloud and try to learn them. A sample card, with RIL-hunter on it, was used for the instructions. Cards were turned face down between E and S. E exposed a card to S every 3 seconds, guided by the flashing light of a Franz metronome.

In a pilot experiment, subjects' comments had revealed that they remembered the English meanings more easily than the CVC's. Therefore subjects were also told, before the training session began, that in the next part of the experiment the artificial words would be shown subliminally in the tachistoscope. This was intended to increase their attention to the CVC's.

Procedure: Tachistoscopic 'recognition' phase

To provide a brief respite between the training and 'recognition' phases, and to increase the credibility of the 'subliminal perception' deception, S's were first shown the sample word, RIL, at speeds which they could easily perceive, usually .3 sec. If the subject did not see the word, after two attempts, at .3 seconds, time was increased to .5 sec. The subject was then shown the same word, with the indicator set at zero - actually, with the indicator touching the upper edge of the zero line. S could easily observe that E was adjusting the timer of the tachistoscope. At the speed used, only a brief flash of light could, in general, be seen. S was told that this was the 'subliminal' speed that would be used in the experiment. A screen was then set in place to conceal the slides as they were being inserted, the timing indicator remained set at zero, S was handed a numbered deck of 48 3 X 5 cards on which to write the artificial word 'flashed' and its meaning or meanings. (Instructions given are in Appendix A)

Subjects were permitted as much time as they required to write the answers, and encouraged and reassured when they commented they could see nothing. On occasion, but rarely, subjects were permitted to 'see' a slide again before going on to the next one.

The usual reaction of subjects when shown the sample word, RIL, at the 'subliminal' speeds, was 'you've got to be kidding!' Some expressed concern over their inability to see anything, and doubt about whether their results would be useful and/or their performance good. In spite of their uneasiness, and in spite of the very rapid speeds used (unknown, but less than the smallest unit on the machine, which was .01 sec.) some subjects <u>did</u> see the slides. Three subjects, whose responses clearly showed that they had seen the slides, were discarded and replaced prior to analysis of the data. Interestingly, one of the subjects, who appeared very concerned about his inability to 'see' anything, was one of the three so discarded.

RESULTS

Unlike the Rubenstein et. al. study with natural English words, the frequency with which homographic CVC's were emitted in our study was not greater than the frequency for non-homographs. On the contrary, for three of the four presentation frequencies, the non-homograph response frequencies appear greater. For the remaining frequency (f=8), the entry for non-homographs, appears quite deviant. (Table I)

Frequency of presentation did, in general have an effect, the more frequently a word was presented in the training session, the more frequently it was guessed in the 'subliminal perception' phase. Correlation between obtained and predicted order, for homographs and non-homographs combined, was 1.00, as measured by Kendall's Tau. This has a significance value of $p < .05$ for 4 ranks. Once again, the entry for non-homographs for f=8 deviates from the trend observed elsewhere. The reasons for this deviation are not known.

Upon inspection of Table I, it appears that the homograph and non-homograph results might be approximately equal. We attempted to compare each curve (line) with the predicted one based on logarithms of the frequencies but the outcome was not entirely clear-cut. The homograph curve was not significantly different from the prediction, but the non-homograph curve was significantly different. (χ^2 - One sample test, d.f. =3, $p \leq .01$) The largest factor, by far, in the calculations was the deviant f=8 entry. We are thus severely tempted not to place too much reliance on the statistical difference found. We cannot, however, conclude, on the basis of these statistical tests, that the homograph and non-homograph curves are the same.

If, however, we assume the results that we cannot support statistically, but which appear very likely from inspection of the data, these results could be interpreted to indicate that the emission frequency of a homograph was a function of the (logarithm of) the sum of the frequencies of its meanings. (Emission frequency was a function of presentation frequency, which in turn was the sum of the frequencies of the meanings)

In general, subjects did seem to have learned most of the CVC's in the experiment. We considered that a CVC had been learned by a subject if he emitted it at least once during the tachistoscope task. More words presented frequently were, of course, learned than words presented with low frequencies. All subjects learned the f=16 words, while about half knew the f=2 ones. In descending order of word presentation frequency, the number of subjects having learned the word was, for homographs: 24, 23, 19, 14, and for non-homographs: 24, 18, 18, 12.

To see if the results in Table I would be substantially altered by correcting for the fact that some CVC's had not been learned, we calculated the mean number of emissions, per combination of conditions, per subject. Table II shows these data, with the mean taken over all 24 subjects, and Table III shows the same data, but corrected for words not learned (mean taken only over subjects who knew the word). The relative order of homographs and non-homographs was not altered by this correction; the anomalous f=8 entries remained deviant; and the order of the overall emission frequencies remained the same, with the values, however, larger at the lower frequencies than for the uncorrected means.

In general, subjects did know which words were homographs and which had only one meaning. For non-homographs, almost all their identifications were correct; for homographs, the correct identification of a word as a homograph or not depended on the frequency. (Table IV) As might be expected, identification was better for words presented more frequently.

Subjects also appeared to have learned the meanings of the words, once again, depending on frequency of presentation. (See Table V)

DISCUSSION

The major interest of this experiment was in the homograph effect, which did not appear in the results. Since the mechanisms underlying the homograph effect, when it does appear, are unknown, it is sheer speculation to search for the reasons for its non-appearance here. Let us, however, speculate.

The present experiment is, of course, not strictly similar to the natural language situation. While we are calling the

CVC's "words in an artificial language" and the paired associates their "meanings", this is primarily an experimental stratagem. Our calling the CVC's "words", for purposes of experimentation, should not mislead us into thinking of them as such. What is missing, of course, is the rest of the language, particularly the other associations, verbal and situational, which our CVC's do not have. It is not beyond the realm of speculation to suppose that these other associations, missing in this experiment, might play some role in producing the homograph effect.(1)

A slight detour is necessary to clarify this. In designing the experiment, we worried about a possible artifact: could the frequency with which an individual experienced a homograph in this experiment be greater than the frequency with which we were presenting it? It could if the following occurred: each time a homograph was presented to S with one meaning, he could at the same time recall the word and covertly repeat or rehearse the other meaning. Given the task and the instructions, this would not be an unreasonable strategy to follow, and would have resulted in a total frequency of experience for the homograph which was greater than the frequency of presentation.

It is possible that a similar mechanism occurs with natural language, and that consequently the frequency with which homographs are experienced is greater than the frequency estimates we are obtaining from the Thorndike-Lorge counts. But intuitively this is not too appealing. The fact of homography comes with a sense of surprise.(2) This is why we are so often amused by it.

And it does not seem entirely reasonable, given our surprise, that covert (conscious) recall (or at least, activation or readying) could be taking place.

There is, however, a less direct way in which the effective frequency - the frequency which actually contributes to the homograph and/or frequency effects - could be augmented. We require several assumptions:

1. When a word occurs in a person's experience, the response strength (like habit strength) - or predisposition to respond with that word in a later recognition task - increases. (This simply says: the more frequent the word, the more likely the response).

2. When the response strength of a word increases, the response strengths of words associated with it increase, but to a lesser extent. (This would be a kind of associative generalization.)

3. Homographic words have more associations in common than words chosen at random. Thus if one meaning of a homograph occurs, the response strengths of <u>its</u> associated meanings will increase, and consequently the response strengths of words associated with the <u>other</u> meanings, which are common, also increase. This effect should occur with any words that have associations in common.

4. The word frequency effect depends, not only on the response strengths of the words in question, but also on the response strengths of its associates.

In essence, we are suggesting that the effective frequency of a word might depend only partially on the frequency with which it has been encountered, and also partially on the frequency of its associates. Furthermore, the homograph effect might depend on changes in the effective frequency of one meaning when the other occurs.

If so, or if the homograph effect depends in any way on the presence of associates, the absence of such associates might account for our failure to find a homograph effect here.

One other suggestion for our failure to find a homograph effect bears mention. This experiment was in part an experiment involving short-term memory. But long-term memory is involved in experiments using natural language words. Baddeley and Dale,(1966) looking for retroactive interference, with semantically similar materials, in both LTM and STM, found the interference effects in LTM but not in STM. They suggested, on the basis of this and other experiments, that encoding in LTM is semantic, whereas in STM it is acoustic. If they are correct, since the homograph effect is basically semantic, it is possible that it simply will not appear in experiments involving STM.

<u>SUMMARY</u>

Subjects were taught CVC's, some with one meaning, and some with two, in a paired-associate task. They then guessed the CVC's in a tachistoscopic 'recognition' task which they had been lead to believe was on subliminal perception.

Results were that the frequency of emission of homographic CVC's, with two meanings, was not greater than the frequency of

non-homographs which had been presented the same number of times in the paired associate-task. Thus the homograph effect observed with natural English words in Rubenstein _et_. _al_. was not observed in this study. Subjects were aware of which words were homographs and which were not. A frequency effect was obtained: overall frequency of emission in the tachistoscope task was a function of the presentation frequency in the paired associate-training phase.

Some very speculative suggestions for the non-occurrence of a homograph effect in this study are discussed, and one possible mechanism for the occurrence of the effect in natural language suggested briefly.

APPENDIX A

INSTRUCTIONS TO SUBJECTS

General: There are two parts to this experiment. I'll go over the whole thing at first, to give you a general idea of the experiment, then we'll go back over each part. This first part is like learning a foreign language. Here on the left (on these cards) is a word in an artificial language. Here on the right is its meaning. I'm going to ask you to read aloud the foreign word and its meaning and to try to learn the word and its meaning. Then we are going over here to the tachistoscope. A tachistoscope is an instrument which flashes words or other materials very briefly. I'm going to flash the foreign words for you in the tachistoscope. But I will flash them very briefly, so briefly you probably won't be able to see them consciously. It will probably feel to you like guessing. This is an experiment on subliminal perception. We want to see if the word registers subconsciously. I'm going to ask you to write the foreign word and its meaning.

Word Association Task: I want you to read aloud the foreign word and its meaning and try to learn the word and its meaning. Some cards appear only once in this deck. Some of them appear more than once. But all the foreign words that occur in the deck, even those that occur only once or twice, will be used later in the tachistoscope. There is one more detail. Sometimes you will see a foreign word you have already seen, but with a new meaning. I want you to do just what you did before: read the card aloud and try to learn the word and its meaning. We will go through this deck. This (card) is a sample only. (RIL-hunter). It will not be used in the tachistoscope. This is just a timer I am using to show you the words at a fairly even pace. You don't have to be concerned with it. Questions?

Tachistoscopic phase

First, I am going to show you the tachistoscope. I am going to flash the sample word, at a speed you can see, so you can see where the words are placed. Then I'm going to show you the same word at the speed we will be using in the experiment . . .

Now, I am going to flash the foreign words in the tachistoscope. I will flash all the foreign words, even those you have only seen once or twice. The same word may be flashed more than once, but never in succession, never following itself. This will probably be too fast for you to see. It will feel to you like guessing. The experiment is on subliminal perception. We want to see if the word is seen subconsciously.

I want you to write the foreign word, together with its meaning or meanings. If you can't remember the meaning, write one X if you think the word had one meaning and two X's if you think it had two. If you remember one meaning and not the other, write the meaning you do remember and an X for the other. We want to see if you know the number of meanings even if you don't remember what they are.

Be sure to write a foreign word on each card. The sample card will not be shown. Turn over the card when you are done. Questions?

APPENDIX B

TABLE I

Frequency of Presentation

	16	8	4	2	Total
Homographs	209	183	111	58	561
Non-Homographs	251	115	118	66	550
Total	460	298	229	124	1111

Total number of emissions per combination of conditions, pooled over 24 S's.

TABLE II

Frequency of Presentation

	16	8	4	2
Homographs	8.71	7.62	4.62	2.42
Non-Homographs	10.46	4.79	4.92	2.75
Mean	9.58	6.20	4.77	2.58

Mean number of emissions per combination of conditions, per subject. Mean taken over 24 S's. (Table I ÷ 24)

TABLE III

Frequency of Presentation

	16	8	4	2
Homographs	8.71	7.96	5.84	4.14
Non-Homographs	10.46	6.39	6.56	5.50
Mean	9.58	7.18	6.20	4.82

Mean number of emissions per combination of conditions, per subject, corrected for words not learned. Mean taken over number of subjects emitting the relevant words at least once. (Table I ÷ corrected number of subjects)

TABLE IV

Frequency of Presentation

	16	8	4	2
Homographs	.82	.81	.77	.34
Non-Homographs	1.00	.99	1.00	.97

Percentage of correct identifications of words as homographs or non-homographs. Denominator is total number of emissions in the relevant combination of conditions.

TABLE V

Frequency of Presentation

	16	8	4	2
Homographs	.92	.82	.76	.52
Non-Homographs	.98	.94	.97	.83

Percentage of Meanings Correct.
Denominator is total number of emissions in the relevant combination of conditions for non-homographs, and the total number times two for homographs. Each of the two meanings of a homograph was included separately in the tabulation.

FOOTNOTES

(1) In designing the experiment, the m-values of the CVC's were chosen to be approximately equal. This was done to preclude the possibility of different numbers of associations influencing the results. But a control device used to preclude effects does not ensure their existence. The associations to the CVC's, while equal, might not have had any effect at all. Since CVC's of other (high) associations were not included in the experiment, there is no way of checking this.

(2) I understand 3rd graders are still telling the: What did one ink blot say to the other? My pa's in the pen doing a sentence--type jokes. These are essentially based on the homographs. The point here is that homography is unexpected, and amusing because of it.

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VITA

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Publications and Talks:

1. "Construction of a Growing Thesaurus by Conversational Interaction in a Man-Machine System", Automation and Scientific Communication, Proceedings of the 26th Annual Meeting of the American Documentation Institute, November, 1963.

2. "Construction of Authority Files", Sixth Annual Institute of Storage and Retrieval, American University, Washington, D.C. Invited talk, February, 1964.

3. "Towards Design and Evaluation of Indexing Systems for Information Retrieval", Air Force report AF 30(602-3303) quarterly report no. 2, May, 1964.

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6. "A Note on Minimizing Search and Storage in a Thesaurus Network by Structural Reorganization of the Net", Information Science, ibid.

7. "Construction of Authority Files", Information Systems Compatibility, S. Newman, ed., Spartan Books, Inc., 1965 (same as No. 2, above)

8. "Evaluation of a Growing Thesaurus", Lehigh University, Seminar in the Information Sciences, Invited talk, March, 1966.